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(Compliments of the Author.)

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In considering the different food-stuffs, we must regard water as of prime importance. In the average adult this body constitutes from fifty-nine per cent. to sixty-five per cent. of the entire weight. Older observers have given this proportion somewhat higher; thus Bernard, following Chaussard, gave the average proportion of water in the human economy as ninety per cent. This, however, was far too high, the error lying in the desiccation of the cadavers investigated, which were in this case subjected to destructive distillation. Of the entire water of the body, we find fifty-five per cent. in the muscles and only three per cent. in the cerebro-spinal system and nerve trunks. We further find the amount correlated with the age of the individual; thus, in mice, there is found in the embryo eighty-seven per cent. of water; in the new-born, eighty-two per cent., and at eight days old, seventy-six per cent.; in the adult mouse, seventy per cent. In advanced age, in all mammalia, the tissues are again rich in water as in early youth. As the result of bad nourishment also, the organism becomes richer in water; thus, a carnivore (*e. g.*, a dog) fed on bread will lose relatively little in weight, but will lose much urea, which substance, it need scarcely be said, is a result of the disintegration of the nitrogenous tissues of the body, such as muscle. On feeding him with meat he at once loses weight and passes by various channels far more water than is ingested, although he is in reality gaining in flesh. A bread or potato diet favors the accumulation of water in the tissues of the human economy, also with the resultant false appearance of health and misleading plumpness of the individual. On returning, however, to a normal dietary containing the proper proportion of proteid material, there is a similar decrease in weight, and the water leaves the body literally in streams. We must regard water as an essential condition for the manifestation of all vital phenomena. It is a common carrier of pabulum to each minute part, and at the same time a scavenger for the removal of the waste products. Most chemical reactions

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and the action of ferments require water, as do also the molecular movements of nerve-conduction and muscular contraction.

The percentage of water in organs cannot be greatly altered without corresponding disturbances in health. In certain diseases, as cholera, there is a diminution in the percentage of the water contained in the tissues of from five to six per cent. As a result of this, however, the blood becomes thick and slow in its movement, urine is no longer excreted, and further removal means the death of the individual, or, in the lower forms of life, a suspension of all the vital activities until such time as the water removed shall be restored. Thus, the common wheel-animalcules may be completely dried and kept, free from moisture, as an impalpable powder; but on the addition of water to this powder the animals in question immediately resume all vital activities, and if subjected to microscopic examination cannot be distinguished from other living and moving infusoria of the same genus.

In the adult human body water is constantly lost by urine, fæces, skin and lungs, chiefly, however, through the former channel. The amount of water daily eliminated varies from two to three litres. It is renewed and its normal proportion maintained by various drinks, the fluid portion of foods, and by the oxidation of carbohydrates. By this last method alone from three-fourths of a pint to one pint of water is daily formed in the average adult body. No decomposition of water occurs in the economy.

In starvation the percentage of water is not decreased in spite of constant losses. This is due in part to production of water by the oxidation of carbohydrates, just mentioned, and to the fact that as the albumens of the body are destroyed in starvation the water which was combined with them becomes free. On this account combined hunger and thirst is more easily borne than thirst alone. Excess of water ingested only temporarily increases the water percentage of the various organs, the loss by the kidneys, etc., being almost immediate; but before its excretion this excess of water must circulate from cell to cell throughout the entire body, and in so doing it not inconsiderably increases the activity of the tissues. Thus, in experiments upon himself, Genth found that in his usual daily life he excreted from forty to forty-five grammes of urea. When, however, he drank from two to four litres of fluid in excess of his habitual amount, the amount of urea excreted was

from forty-six to fifty-five grammes; that is, an increase of from fifteen to twenty-two per cent.

In children, with whom both tissue-activity and tissue-destruction is very great, there is again a great demand for water, and an interesting clinical fact, first emphasized, I believe, by the late Dr. Meigs, of this city, is that in the great majority of cases in which children cry without apparent cause, the origin of their distress is lack of the water needed to wash away the products of tissue-change.

From a hygienic standpoint it is of the greatest importance that the water drunk shall be pure, and the following brief rules by Fischer, perhaps the best authority upon this matter, will be found of service:

The water must be clear, colorless and odorless. The extremes of temperature through which it should exist at different times of the year are narrow, viz., from 6° to 12° C. (40° to 50° F.). It must not contain more than the most minimal amount of organic matter ($\cdot 04$ of one per cent.), absolutely none of the organisms of decay, bacteria, etc. It must contain no ammonia or nitrous acid, and less than one-tenth of one per cent. of nitrates, sulphates and chlorides. It must not contain more than $\cdot 04$ per cent. of magnesia, and, of course, no poisonous metals.

Certain solid inorganic elements of food are absolutely essential to the well-being of the organism, for in their absence the tissues cannot be properly built up, nor can the processes in either the solids or the fluids of the body go on. But for the constant renewal of these inorganic or ashy constituents of the body, not only would the characteristic activity of gastric and pancreatic juice and bile sooner or later be rendered impossible but some of the inorganic materials already existing in the tissues would be seized upon by the various acids—uric, sulphuric, etc.—which are constantly developed in the retrograde metamorphosis of tissue and be excreted as salts, with a resultant loss of the normal degree of alkalinity of the juices of the body and finally death. The presence of mineral constituents appears absolutely essential to the integrity of proteid matter, and their withdrawal entails a loss of most of its distinguishing characteristics. We find no coagulable proteid without its quota of inorganic salts, and these salts appear to be in a state of chemical union with the albuminoid. Thus in the

lowest organisms, as the amœba, we find an appreciable quantity of alkaline salts, notably phosphates. Casein also is a proteid body remarkable for the tenacity with which it holds incorporated with it a large amount of phosphate of lime. Now, inasmuch as these inorganic constituents of the body are constantly passing from the economy in the excretions, they must as a consequence be renewed. The full importance of these substances was first appreciated by Liebig, whose attention was directed to the subject by his studies in agricultural chemistry. Since the overthrow of his views as to the rapidity of tissue waste and repair, the subject of the inorganic food-stuffs has not received the attention which its importance merits. The question of the amount of this form of food which is essential to the organism is as yet unsettled. Certain it is, however, that in earlier life relatively greater quantities of the salts are needed, and that their absence from the food at this period produces results much more marked and immediate than would the same conditions in adult life.

In starvation there is a continual elimination of the inorganic salts, which is explained by the fact that these salts are constantly set free in the destruction of the circulating albumens with which they were previously in comparatively firm chemical combination. When, on the other hand, there is attempted the so-called salt starvation, viz., the administration of proteids, fats, carbohydrates and water, all in ample quantity, but from which all existing salts have been removed, the excretions are marked by a nearly complete absence of the inorganic salts. The cause of this apparent anomaly lies in the fact that the salts which were combined with the albumens of the tissues and circulating fluids are by the normal disintegration of these albumens set free, but instead of being eliminated they enter into immediate combination with the newly-introduced saltless albumens of the circulation. This can endure, however, but for a relatively short period; for in such recombination there is an inevitable failure to unite of a portion of the salts, which are thereupon excreted, resulting in such a diminution of the ashy constituents of the body as ultimately to induce death.

Pigeons thus subjected to starvation by the withdrawal of all inorganic foods die in from thirteen to twenty-nine days, although abundance of the other food constituents may be given them. In twenty-six to thirty-six days dogs similarly treated are reduced to

such a miserable condition that a continuance of the observation would mean almost immediate death. The characteristic symptoms of this species of starvation are muscular weakness and trembling, gradual blunting of the senses, with occasionally heightened reflex activity, and, finally, impaired digestion and death. No well-marked changes are found in the bones of adult animals, which have died under this regimen; but with young animals the case is different. Young pigeons of the same age have been fed with wheat from which the major portion of the inorganic materials was removed by maceration; to one series of these pigeons this wheat was given with distilled water; to another series was given the same wheat with brook-water, in which bits of mortar were allowed to stand. All the animals grew for a time, but those of the first series all died, exhibiting the symptoms of rachitis, while those of the second series remained to all appearances in good health. An examination of the bones showed that those of the pigeons receiving no inorganic salts contained full ten per cent. less of solid matters than did those of the normally fed. Apart from the absence of lime salts in the food, diseases of the bone may supervene in young animals in which protracted diarrhoea or other digestive disturbances have prevented the proper absorption of inorganic foods.

Perhaps the most striking illustration of the necessity of this class of food stuffs, and also of the disturbances resulting from a very slight diminution in the amount of inorganic constituents present in the economy, may be found in the recent experiments of Ringer. In these experiments minnows were placed in distilled water which was properly aerated. They died in a few hours. Minnows of the same age were similarly placed in brook-water, and remained alive without any food for many days. An examination of the distilled water in which the minnows had so speedily died, revealed the presence of minute traces only of inorganic bodies, which had evidently dialyzed out from the body of the fish into the surrounding medium—a loss so slight as scarcely to be estimated, and yet sufficient to entail the destruction of the individual.

Examining now the inorganic elements of food somewhat more closely in detail, we find them to consist of the salts of the alkalis, salts of the alkaline earths, and of iron, silica, and fluorine in

various combinations. There are also found in the excreta several bodies which have been erroneously regarded as excreted inorganic food-stuffs, which are really products of tissue-activity. As instances in point may be noted, the carbonates and sulphates of the urine, which proceed almost exclusively from the breakdown of vegetable acids and of proteid tissues respectively. The compounds of the several alkalis with chlorine and with phosphoric and carbonic acids are differently distributed, as was first noted by Liebig. Thus in the firmer tissues, as is notably the case in muscle, there is found a preponderance of salts of potassium, while in the circulating fluids and juices of the body, the sodium salts are found in greater abundance. The salts of the alkalis are chiefly removed from the body in the urine, being scarcely to be found in the fæces of carnivora, and when found in the fæces of men and animals, on a mixed diet, they arise from the imperfect absorption of foods which contain them. In diarrhœa, and in the semi-fluid excreta of many herbivoræ, they are present in notable quantity from the same cause. Under normal conditions the alkaline reaction of the saliva is due to the presence of salts of sodium; but in inflammatory conditions of the mouth-cavity the dominant salts secreted are those of potassium. This fact would seem correlated with the observation of Mannassein, that in fever the amount of the salts in the muscles is diminished, as a result of which there is excreted in urine three to four times as much potassium in fever as in health. A similar action is also observed in starvation.

The nature of food, and to a large extent, the nature of its inorganic constituents, imparts characteristic reactions to the urine; thus vegetable foods as a rule contain a notable excess of the alkaline salts of potassium, and we accordingly find in the urine of herbivoræ a decidedly alkaline reaction. When, however, an herbivorous animal is placed upon animal food, as is the case with a sucking calf, or what is the same thing, a starving cow which is consuming its own tissue, the urine assumes an acid reaction, due to the presence of acid sodium phosphate. The rationale of the secretion of acid fluids is but imperfectly understood. Ralfe has pointed out that under the influence of a weak electric current a decomposition occurs between neutral sodium phosphate and sodium bicarbonate, both of which exist in the blood, with the production of the acid sodium phosphate and normal sodium bicarbonate. This view is in some measure confirmed by the

repeatedly confirmed observation that an increased acidity of the urine occurs after the administration of the bicarbonates of potassium, sodium and ammonium.

The importance to the economy of the carbonates of the alkalies, and therefore the importance of fresh vegetable food from which they are most readily elaborated, must not be underestimated. To them is largely due the alkalinity of the circulating fluids of the body, an alkalinity whose disturbance is inevitably fatal. Reduction of the alkalinity of the circulating fluids is, however, difficult to attain; amounts of dilute acid have been introduced into the stomach, and without marked disturbance, which, if absorbed and excreted without change, would have been more than sufficient to render acid all the solids and fluids of the economy. When, however, the floods capable of yielding carbonates as the vegetable acids and the alkalies, are withheld, there is a different result, the elimination of the acids constantly forming in the functional activity of the tissues is retarded, and when excreted they carry with them the salts of the body, with the ultimate production of the symptoms of scurvy. When, therefore, the alkaline constituents of the economy are for a long time withheld, we note diminished alkalinity of the circulating fluids, with dissolution of the red corpuscles, ecchymoses on the mucous surfaces of the heart and mediastinum and fatty degeneration of the heart and general muscular system, and also of the glandular organs.

The production of a free acid, viz., as hydrochloric acid in gastric juice, from an alkaline fluid, the blood, presents a problem of some interest. It has been explained by the double decomposition occurring between acid sodium carbonate and sodium chloride, with the resultant production of normal sodium carbonate and hydrochloric acid. Some observers would substitute calcium chloride for the sodium chloride in the reaction just given; but in any case the principle is the same. That the hydrochloric acid once formed should leave the blood for the stomach is not incomprehensible, for the diffusive power of this acid ranks among the highest. Such reactions as these are valuable accessions to knowledge; and are very necessary steps in our approximations to ultimate truth; but why such reaction should occur in the stomach and not elsewhere is as yet unknown.

Of the uses of potassium chloride but little is known. Sodium

chloride, however, has been more closely studied. The infant at the breast receives daily on an average during its first year about twelve grains ($\cdot 79$ of a gramme) of salt. The adult undoubtedly takes proportionately more, and this excess can be regarded as of value chiefly as a condiment; that is, as a stimulant to appetite and digestion, which acts by pleasing the sense of taste. Salt when introduced into the economy, either by the stomach or directly into the veins, begins to appear in the urine within an hour thereafter. The maximum of excretion is reached in the third hour, and in eight hours it is all eliminated. A curious mutual relation exists between the salts of potassium and those of sodium; an excess of sodium chloride in the food produces an increased renal elimination of the salts of potassium. The converse also holds good, viz., an excess of potassium salts in foods induces a rapid excretion of sodium chloride to such an extent that intense salt hunger is experienced. This is not felt by men and animals living upon a food relatively poor in potassium. To men fed, as are to a large degree the poorer classes in many countries, upon products of wheat, rye, potatoes, and the leguminosæ, all of which are relatively rich in potassium, salt becomes more than a condiment; it becomes an indispensable food, for it withdraws the potassium salts which otherwise—it would seem chiefly by their action upon the nervous system—poison the economy. Common salt in such proportions as the healthy taste demands is undoubtedly a valuable stimulant to the nutritive processes. All agriculturists agree that the herbivorous animals of the farm thrive better upon the addition of salt to their food. It is further well known that the withdrawal of common salt from the food of domestic animals induces many symptoms of impaired nutrition.

We have already discussed the absolute necessity for lime-salts in young animals, but the extent of this need is surprising. The experiments of Soxhlet, Lehman, and Weiske coincide in showing that for the calf at ages of from two weeks to five months there is needed from ten to fifteen grammes of calcium daily. A large proportion of the lime salts used in the human body are obtained from drinking water.

Iron, popularly regarded as a drug, is undoubtedly a food, for concurrently the iron in the tissues and fluids of the body is being separated from its inorganic combinations and eliminated while the

fresh increments are being taken up from the food. Its avenue of elimination is almost exclusively by the fæces, though traces are to be found in the urine. Contrary to popular belief, the major portion of the iron of the human body is found, not in the blood, but in the muscles, even after their contained blood has been removed. It must, therefore, be borne in mind that the amount of iron found in the excreted matter is not a direct indication of the extent of the disintegration of hæmoglobin. The precise amount of iron which is needed daily by the average adult is not fully established, but it is evidently quite small. Perhaps the best approximation to the amount required may be obtained from the analysis of the normal mother's milk. On this basis an infant during the first year uses daily three and one-third milligrammes of iron, or in other terms, a trifle less than twenty grains a year. In the healthy adult, in whom tissue waste is not so pronounced, and with whom also there are no claims for the process of growth, it is probable this amount will be fully sufficient if presented in the appropriate form for its proper assimilation.

Silicic acid is found in very small quantities in bones, hair and blood. It is supplied by many vegetable foods. Calcium fluoride is found in teeth, and to a slight extent in bone.

Fortunately for us; these inorganic foods, whose withdrawal, as we have seen, exercises such deleterious influences on the economy, are, as a rule, present in great quantity in the actual foods in a mixed diet. In certain methods of preparing foods, however, their proportion is much diminished; thus, in the boiling of meats and vegetables, a large quantity of these important food-stuffs is extracted. Indeed, one of the chief dietetical advantages of salads and uncooked vegetables in general is that these elements have not been removed.

There is a very rational and economical method employed in French family cookery, which it would be well to employ in this country. This consists in the use of a large pot, whose contents are kept constantly at a gentle heat, and into which is poured all the water in which meat and vegetables have been boiled. After some simmering down, this extract, with some addition of flavoring, forms not only a good and appetizing soup, but retains as a food what otherwise would have been lost, viz., the inorganic food stuffs whose value we have just considered.

